Imager for Magnetopause-to-Aurora Global Exploration

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The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission, led by Dr. James L. Burch of Southwest Research Institute, is the first for all-remote sensing of the Earth's magnetospheric environment. Almost 40 years of point-by-point, in-situ measurement of particles and fields in the terrestrial magnetosphere has led to a detailed understanding of micro- and meso-scale physical processes. The modern challenge in magnetospheric physics is the synthesis of these scattered measurements in space and time into a coherent global picture of energy transport from the solar wind into the ionosphere and particle transport from the ionosphere out into the magnetosphere. The IMAGE mission will provide images of the time-changing ring current, plasmasphere, aurora, and magnetopause. The global morphology of these individual plasma systems and the interrelationships between them will be revealed in a way never before possible.

Along the 45,000-km by 1,000-km altitude polar orbit, six instruments will remotely measure the state of the magnetosphere. Energetic neutral atoms (ENA) emitted by magnetospheric plasmas will be imaged in three energy ranges, low (10 to 300 eV), middle (1 to 30 KeV), and high (10 to 200 KeV). These instruments will measure ENA produced by ions flowing out of the ionosphere at auroral latitudes and produced by energetic ring current ion populations as these populations dynamically respond to magnetospheric storms and substorms. Extreme ultraviolet (EUV) solar light scattered by He^+ ions in the plasmasphere will be imaged by the EUV camera. This cold population of plasma can be used as an indicator of the electric convection forces that dominate storm-time dynamics in the inner magnetosphere. The aurora will be imaged in far ultraviolet light and be used as a familiar guide to the dynamic state of the magnetosphere. The densities and motions of magnetospheric plasmas will be sampled remotedly by the radio plasma imager (RPI). The RPI will broadcast coded pulses of radio waves from 3 kHz to 3 MHz and measure the direction of arrival, time delay, and frequency of returning echos.

Researchers in the MSFC Space Plasma Physics Branch are participating in the university, industry, Government partership that comprise the IMAGE team. Our role involves participation in the development of flight instrumentation, environmental modeling, and the development of data analysis techniques. Led by the Applied Physics Laboratory at Johns Hopkins University, MSFC is participating in the development of the high energetic neutral atom (HENA) camera. This instrument will measure energetic neutral atoms of hydrogen and oxygen. These atoms are produced with high-energy ring current ions that are neutralized through collision with the cold neutral hydrogen gas that extends to high altitudes from our terrestrial atmosphere. The development of auroral cameras is led by the University of California at Berkeley. MSFC is responsible for working with researchers in Canada to provide the wideband imaging camera (WIC) that will measure the far ultraviolet light produced when electrons bombard the upper atmosphere, producing auroral light.

The IMAGE theory and modeling effort is jointly led by MSFC and Rice University. Modeling is required for this mission for the purpose of defining necessary instrument capabilities and for the purpose of preparing the necessary techniques that will be required to interpret the measurements that will be returned. The approach taken by the theory and modeling team has been toward the development of a single, consistent time dependent model for the magnetosphere. The model component for the plasmasphere will be used together with the model for the ring current in order to compute ring current decay due to collisions. Ring current losses into the auroral ionosphere will be used to estimate diffuse auroral photon emissions and to estimate precipitation-driven outflow of plasma from the ionosphere. To these plasma systems, models are being added for polar cusp and magnetosheath plasmas. All models will be "geared" to conditions in the solar wind and all will share use of the Rice magnetospheric specification model (MSM) for the computation of convection electric fields. The Rice Toffeletto-Hill magnetic field model will also be shared by all team members for defining the terrestrial magnetic field near the Earth and at high latitudes.

MSFC and associated researchers are involved in modeling the plasmasphere, the ring current, and auroral ionospheric outfow. This modeling is now being used to support decisions related to the detailed designs of ENA cameras and the EUV camera. An example of that modeling is shown in figure 177. The intensity of scattered solar ultraviolet light at 30.4 nm is shown for a noon-midnight scan across the inner magnetosphere, as would be seen by an observer located about 45,000 km above the north magnetic pole. The scan is centered on the Earth and negative angles are toward the Sun. The reduced intensities at positive angles is because much of this plasma is in the Earth's shadow. The intensity hole at small angles is due to the greatly reduced He^+ densities over the polar region. The density peak at small negative angles is due to the dayside ionospheric density peak in He^+ ions. The plasma-spheric regions of particular interest in the IMAGE mission are those in the outer plasmasphere, where densities and consequently intensities are relatively low. The EUV instrument, therefore, must be designed with sufficient sensitivity to see scattered ultraviolet light with intensities as low as a 0.1 Rayleigh, while avoiding saturation by intensities close to the Earth, that may be more than 150 Rayleighs.

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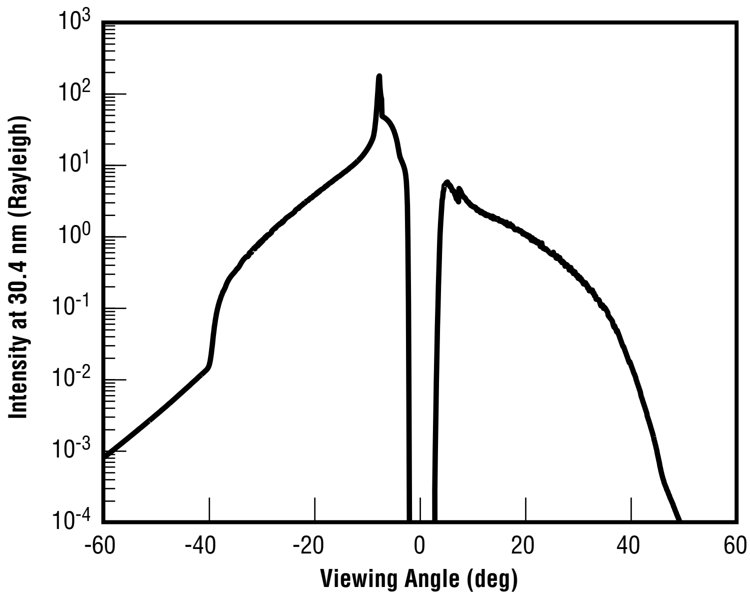

Figure 177.—The intensity of 30.4 nm solar radiation scattered by He^+ ions in a model plasmasphere is shown for an observer located at an altitude of about 45,000 km over the North magnetic pole.

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Biographical Sketch: Dr. Dennis L. Gallagher received his Ph.D. in physics at the University of Iowa in 1982. He joined NASA/MSFC in 1984 with responsibilities for conducting magnetospheric plasma physics research and for coordinating the use and development of computer and networking resources for the Space Sciences Laboratory. Today Gallagher is dedicated exclusively to space plasma research and is a co-investigator in the IMAGE mission. His primary focus is on the modeling and simulation of cold plasma ions in the inner magnetosphere.